COMPARATIVE TESTING OF PIPELINE SLURRY MONITORS

TECHNOLOGY DESCRIPTION

The purpose of this project is to evaluate and provide in-line instrumentation for the real-time monitoring of slurry properties critical to pipeline transport (e.g., density, suspended solids concentration, viscosity, and particle size distribution). Instruments that have been and are being examined work on the principles of the Coriolis effect, ultrasonic reflection coefficient, gamma-ray attenuation, ultrasonic impedance, ultrasonic attenuation, quartz crystal resonation, U-loop pressure drop, image processing, and the backscattering of light. Current work is focused on providing a real-time monitor for the measurement of suspended solids concentrations based on simultaneous monitoring of slurry density and filtrate density with Coriolis meters.

The technology will be used to prevent the plugging of pipelines during transfers of radioactive slurries. In general, the transfer properties of the slurries will be determined and adjusted as necessary prior to making a transfer. These properties will also be monitored during transfers to ensure that they remain within design limits. This is especially important for the heterogeneous wastes stored at U.S. Department of Energy (DOE) sites. The technology currently used to obtain these properties is grab sampling and laboratory analysis. In-line monitoring is more efficient because the results are available continuously and in real time. Consequently, operating personnel can take immediate steps to prevent pipeline plugging, and to minimize personnel exposure to radiation.

TECHNOLOGY NEED

DOE has millions of gallons of radioactive liquid and sludge wastes stored in underground tanks at its Hanford, Savannah River, Idaho, and Oak Ridge sites. These wastes must be retrieved from the tanks and processed to a final waste form. For removal from the tanks, the sludge wastes will typically be mixed with the liquid wastes to create slurries that are suitable for transport through pipelines to a treatment facility. Depending on the site, the slurries may have to be transported several miles. Because the wastes are radioactive, it is critical that the slurries be transferred without plugging the pipelines.

The technology is being demonstrated and deployed at Oak Ridge National Laboratory (ORNL), but it is also of interest to the Hanford and Savannah River sites. The applicable Site Technology Coordination Group (STCG) need numbers and titles are as follows:

- OR-TK-04 - Sludge Mixing and Slurry Transport
- OR-TK-05 - Tank Sludge and Supernatant Separations
- ID-2.1.67B - High Level Waste Slurry Handling – Transport/Store Undissolved Solids
- SR00-2044A - *In Situ* Technology for Waste Characterization - Rheological Properties
- SR00-2037E - Tank Heel Removal/Closure Technology - Real Time Data for Pumping
- RL-WT09 - Representative Sampling and Associated Analysis to Support Operations and Disposal
- RL-WT-032-S - Monitoring of Key Waste Physical Properties During Retrieval and Transport
- RL-WT-040-S - Mechanisms of Line Plugging

TECHNOLOGY BENEFITS

Real-time monitoring of slurry properties with in-line instrumentation provides site operators with the data they need for decisions concerning slurry transfers through pipelines. Since the properties are monitored continuously, operators can know in real time if these parameters are steady and acceptable for slurry transfer. The slurry monitoring instruments can also be used during transfer to determine whether the properties remain constant. Thus, operators can respond quickly to prevent plugs in the pipelines as the situation requires. This technology decreases costs by preventing pipeline plugs and by reducing the number of samples that need to be analyzed. This reduces exposure to radiation for personnel (e.g., samplers and analysts) and it minimizes generation of secondary waste.

The baseline technology for determining the slurry transfer properties is sampling and analysis. The following table compares the baseline with in-line slurry monitoring. The conclusion is that the latter is the preferred method. The following is a comparison of methods for determining slurry transfer properties:

Sampling and Analysis

- Sample results represent the slurry transfer properties at the time of sampling.
- Sample results are not immediately available.
- Changes in the slurry properties are detected only when additional samples are collected.
- Sampling and analytical personnel are exposed to radiation.

In-Line Slurry Monitoring

- Slurry transfer properties are recorded continuously.
- Results are available in real time.
- Operators continuously monitor the slurry properties and respond with corrective actions as required.
- Exposure of personnel to radiation is reduced.

If a pipeline is plugged with radioactive waste and the plug cannot be cleared by conventional methods (e.g., back-flushing the pipeline with water), there are two options: (1) locate, excise, and replace the plugged section or (2) build a new pipeline and remediate the plugged pipeline at a later date. Both options are costly, cause scheduling delays, and pose significant risk of worker exposure to radiation.

The benefits of implementing in-line slurry monitoring include the following:

- Avoiding major expenses (over $1M per plug).
- Reducing exposure of personnel to radiation.
- Preventing schedule delays.

TECHNOLOGY CAPABILITIES/LIMITATIONS

In-line monitoring can be applied to a wide variety of slurry properties. The presence of entrained air in the slurries can have a negative effect on the ability of the instrument to measure the transfer properties. The magnitude of the effect depends on the instrument and the amount of entrained air. For best results, entrained air should be reduced or eliminated.

COLLABORATION/TECHNOLOGY TRANSFER

Collaborators have included Argonne National Laboratory (ANL), Pacific Northwest National Laboratory (PNNL), Sandia National Laboratories (SNL), the Savannah River Site (SRS), and Florida International University - Hemispheric Center for Environmental Technology at (FIU-HCET). During FY 1997, ANL, PNNL, and SNL provided prototype instruments for evaluation with nonradioactive slurries. PNNL also provided viscosity analyses (at high shear rate) for these slurries. In FY 1998, ANL supplied a prototype instrument for measuring the suspended solids concentration of radioactive slurries. In FY 2000, ORNL is collaborating with FIU-HCET and the SRS to install a solids monitoring system in an application at the SRS.

The Hanford Site has expressed interest in real-time slurry monitoring and has followed the progress of this project. Fernald has also shown interest in the results of instrument testing, and a private company has inquired about the test program for use in a nonradioactive operation.

Two technical reports that describe the work performed under this project have been published:

- T. D. Hylton et al., *Comparative Testing of Slurry Monitors*, ORNL/TM-13587, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May 1998.
- T. D. Hylton and C. K. Bayne, *Testing of In-Line Slurry Monitors and Pulsair Mixers with Radioactive Slurries*, ORNL/TM-1999/111, Oak Ridge National Laboratory, Oak Ridge, Tennessee, July 1999.
- A paper entitled "In-Line Monitoring of Slurry Transport Properties" was presented at the Waste Management Education & Research Consortium (WERC) Conference on the Environment, held April 27-29, 1999, in Albuquerque, New Mexico.

ACCOMPLISHMENTS AND ONGOING WORK

In FY 1997, in response to Needs Statement OR-TK-04 - Sludge Mixing and Slurry Transport, ORNL personnel conducted slurry monitor evaluations with nonradioactive slurries. Nine pipeline and three in-tank instruments were evaluated for monitoring density, percent-solids concentration, viscosity, and particle size. The current and power requirements of the transfer pump were also evaluated to determine whether they could be used to provide early indication of problems with slurry properties. The results were used to downselect monitors for an FY 1999 evaluation and deployment with radioactive slurries at the Gunite and Associated Tanks (GAAT) project.

A Slurry Monitoring Test System (SMTS) for use with radioactive slurries was designed and fabricated in FY 1998. The SMTS incorporated the most promising technologies from the FY 1997 testing and evaluation: (1) an Endress + Hauser Promass 63M Coriolis meter for monitoring density, (2) a Lasentec M600P for monitoring particle size distribution, and (3) a prototype ultrasonic solids-concentration meter developed at ANL. The Lasentec M600P, which PNNL had tested earlier with nonradioactive slurries, was included with the sponsorship of the Accelerated Site Technology Deployment Program. The SMTS also contained an in-line sampling device and instrumentation for monitoring pipeline pressure, slurry temperature, and power consumption of the pump. A test program was conducted in FY 1999 to evaluate the instruments installed in the SMTS.

The FY 1999 test results indicated that the use of two Coriolis meters was a promising approach for monitoring the concentration of suspended solids in tank slurry. The real-time suspended solids concentration can be computed using the relationship between slurry density (monitored with one Coriolis meter), carrier fluid density (monitored with the second Coriolis meter following removal of the solids), and the density of the suspended solid particles.

The Solid-Liquid Separator (SLS) system at ORNL provided an opportunity to implement this approach. The SLS uses a cross-flow filtration system to separate suspended solids from the carrier fluid so that the fluid can be subsequently processed for cesium removal and volume reduction. An Endress+Hauser Promass 63F Coriolis meter was already being used to measure the density of the slurry. In FY 2000, an additional Coriolis meter of the same type was installed to measure the density of the filtrate. The SLS filters are rated for 5-µm particles, so the density of the filtrate approximates the density of the carrier fluid. The two Coriolis meters will be used together to function as a suspended solids monitor. A photograph of the Coriolis meter apparatus for monitoring the filtrate density is shown in the figure on the next page.

TECHNICAL TASK PLAN/TECHNOLOGY MANAGEMENT SYSTEM INFORMATION

This project has received funding under the following technical task plans (TTPs):

TTP No./ Title: OR17C231 - Comparative Testing of Pipeline Slurry Monitors
TTP No./ Title: OR16WT51 - LMES Retrieval and Closure (Subtask D)
Tech ID/Title: 1547 - Comparative Testing of Pipeline Slurry Monitors

The project has also collaborated with ANL, PNNL, and SNL in the testing of their prototype instruments for measuring slurry properties. Those laboratories were funded under separate TTPs, as indicated in the following listing:

Organization	TTP Number	TTP Title
ANL	CH26C217	Ultrasonic Sensors for *In Situ* Monitoring of Physical Properties
PNNL	RL36C214	*In Situ* Sensor Development - Ultrasonic Density Measurement Probe
SNL	AL26C213	*In Situ* Viscosity and Density Monitoring Using Quartz Resonators

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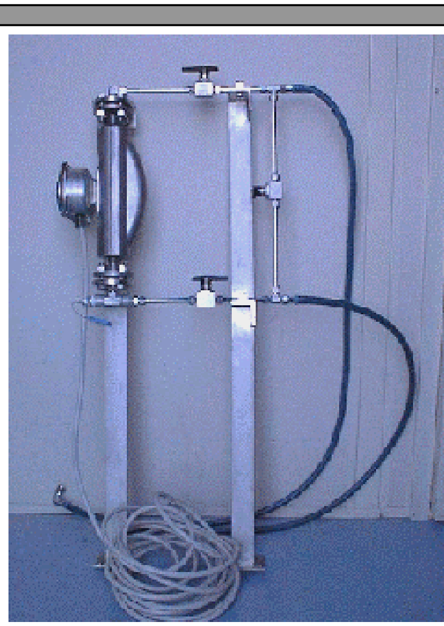

Photograph of Coriolis meter used to monitor the density of filtrate in the SLS.